CLAIMS

What is claimed is:

1. A rotary disk refiner for refining fiber in a liquid stock comprising:

a housing having a stock inlet;

a rotor within the housing that rotates about an axis of rotation during operation and which has a first refiner plate mounting surface;

a second refiner plate mounting surface within the housing that opposes the rotor;

a first refiner plate carried by the first refiner plate mounting surface, the first refiner plate comprised of a plurality of pairs of upraised refiner bars that define grooves therebetween that collectively form a first refining surface;

a second refiner plate carried by the second refiner plate mounting surface, the second refiner plate comprised of a plurality of pairs of upraised refiner bars that define grooves therebetween that collectively form a second refining surface, wherein the second refiner plate opposes and is spaced from the first refiner plate, and wherein a refining zone is defined between the opposed refining surfaces of the first and second refiner plates; and

wherein one of the refiner plates is comprised of a plurality of refiner plate segments, with at least one of the refiner plate segments being a deflection compensating refiner plate segment that has a refining surface with a portion of the refining surface offset to compensate for deflection of the deflection compensating refiner plate segment during operation of the rotary disk refiner.

2. The rotary disk refiner of claim 1 wherein the deflection compensating refiner plate segment has an overhang disposed rearwardly of the portion of its refining surface that is offset to compensate for deflection of the deflection compensating refiner plate segment during operation of the rotary disk refiner.

3. The rotary disk refiner of claim 2 wherein the portion of the refining surface that is offset to compensate for deflection of the deflection compensating refiner plate segment during operation of the rotary disk refiner is inwardly offset relative to another portion of the refining surface of the deflection compensating refiner plate segment.

4. The rotary disk refiner of claim 3 wherein the thickness of the deflection compensating refiner plate segment is reduced in the portion that is offset such that the offset portion is inwardly offset.

5. The rotary disk refiner of claim 2 wherein the portion of the refining surface that is offset to compensate for deflection of the deflection compensating refiner plate segment during operation of the rotary disk refiner is outwardly offset relative to another portion of the refining surface of the deflection compensating refiner plate segment.

6. The rotary disk refiner of claim 5 wherein the thickness of the deflection compensating refiner plate segment is increased in the portion that is offset such that the offset portion is outwardly offset.

7. The rotary disk refiner of claim 1 wherein the refining surface of the deflection compensating refiner plate segment is disposed on a front side of the deflection compensating refiner plate segment and a mount is disposed on a backside of the deflection compensating refiner plate segment, the mount defining a pair of spaced apart overhangs on the deflection compensating refiner plate segment with one of the overhangs disposed along one side of the mount and another one of the overhangs disposed along the other side of the mount, and wherein there are a plurality of spaced apart portions of the refining surface that are offset to compensate for deflection of the deflection compensating refiner plate segment with the offset portions of the refining surface including a first pair of offset portions with one of the first pair of offset portions being disposed in a part of the refining surface that overlies one of the overhangs and the other one of the first pair of offset portions being disposed in another part of the refining surface that overlies the other one of the overhangs, and wherein each one of the offset portions of the first pair of offset portions is inwardly offset to compensate for deflection that occurs to the deflection compensating refiner plate segment during operation of the rotary disk refiner.

8. The rotary disk refiner of claim 7 wherein the mount comprises a dovetail tenon that is received in a refiner plate holder of the rotary disk refiner that comprises a mortise.

9. The rotary disk refiner of claim 8 wherein the dovetail tenon comprises a pair of spaced apart and longitudinally extending legs that define a hollow therebetween that reduces the mass of the deflection compensating refiner plate segment such that outward deflection along a middle portion of the refining surface is reduced.

10. The rotary disk refiner of claim 9 further comprising a pair of transversely extending and spaced apart ribs that each extend from one of the legs to the other one of the legs of the dovetail tenon.

11. The rotary disk refiner of claim 9 wherein the hollow disposed between the legs of the dovetail tenon has a concave shape.

12. The rotary disk refiner of claim 7 wherein the plurality of spaced apart portions of the refining surface that are offset includes a second offset portion of the refining surface (1) that is spaced from the first pair of offset portions, (2) that overlies the mount, and (3) that is inwardly offset to compensate for deflection that occurs to the deflection compensating refiner plate segment during operation of the rotary disk refiner.

13. The rotary disk refiner of claim 12 wherein the second offset portion of the refining surface is disposed at or adjacent the middle of the deflection compensating refiner plate segment.

14. The rotary disk refiner of claim 13 wherein the second offset portion of the refining surface is disposed along a midpoint of the refining surface of the deflection compensating refiner plate segment.

15. The rotary disk refiner of claim 12 wherein the plurality of spaced apart portions of the refining surface that are offset includes a third offset portion of the refining surface that is disposed between one of the offset portions of the first pair of offset portions and the second offset portion, and wherein the third offset portion of the refining surface is outwardly offset to compensate for deflection that occurs to the deflection compensating refiner plate segment during operation of the rotary disk refiner.

16. The rotary disk refiner of claim 7 wherein the deflection compensating refiner plate segment has a leading edge, a trailing edge, an outer edge, and an inner edge, and wherein one of the first pair of offset portions is disposed adjacent the leading edge, and another one of the first pair of offset portions is disposed adjacent the trailing edge.

17. The rotary disk refiner of claim 16 wherein each one of the first pair of offset portions has a portion of maximum offset that inwardly offsets the refining surface between two thousandths of an inch (0.05 mm) and fifteen thousandths of an inch (0.38 mm).

18. The rotary disk refiner of claim 17 wherein the portion of maximum offset of one of the first pair of offset portions is located adjacent the trailing edge of the deflection compensating refiner plate segment and the portion of maximum offset of another one of the first pair of offset portions is located adjacent the leading edge of the deflection compensating refiner plate segment.

19. The rotary disk refiner of claim 18 wherein the magnitude of the offset of each one of the first pair of offset portions decreases generally linearly from the portion of maximum offset.

20. The rotary disk refiner of claim 18 wherein the magnitude of the offset of each one of the first pair of offset portions decreases parabolically from the portion of maximum offset.

21. The rotary disk refiner of claim 1 wherein the rotary disk refiner is a conical disk refiner and the deflection compensating refiner plate segment comprises a deflection compensating conical disk refiner plate segment that has (1) a refining surface with a curvilinear transverse cross-sectional periphery, (2) a backside with a mount extending out therefrom defining a pair of spaced apart unsupported overhangs with one of the unsupported overhangs disposed along one side of the mount and the other one of the unsupported overhangs disposed along the other side of the mount, and (3) a pair of offset portions of the refining surface inwardly offset to compensate for deflection of the deflection compensating conical disk refiner plate segment with one of the pair of offset portions in one portion of the

refining surface that is carried by one of the unsupported overhangs and another one of the pair of offset portions in another portion of the refining surface that is carried by the other one of the unsupported overhangs.

22. The rotary disk refiner of claim 21 wherein the deflection compensating conical disk refiner plate segment has a leading edge carried by one unsupported overhang and a trailing edge carried by the other unsupported overhang, and one of the pair of offset portions is disposed along the leading edge and another one of the pair of offset portions is disposed along the trailing edge.

23. The rotary disk refiner of claim 22 wherein the refining surface has one portion with a circular transverse cross-sectional periphery and each offset portion of the refining surface is inwardly offset relative to the one portion.

24. The rotary disk refiner of claim 23 wherein the one portion of the refining surface that has the circular transverse cross-sectional periphery comprises the majority of the refining surface.

25. The rotary disk refiner of claim 24 wherein during refiner operation at a rotational speed of at least 1500 rpm, each one of the pair of offset portions deflects outwardly a sufficient magnitude such that substantially all of the refining surface has a circular transverse cross-sectional periphery.

26. The rotary disk refiner of claim 23 wherein one of the pair of offset portions has a maximum offset adjacent the leading edge, the other one of the pair of offset portions has a maximum offset adjacent to the trailing edge, the one of the pair of offset portions encompasses a transverse region that extends a transversely inboard of the leading edge a distance of at least one inch (2.54 cm), and the other one of the pair of offset portions encompasses a transverse region that extends transversely inboard of the leading edge a distance of at least one inch (2.54 cm).

27. The rotary disk refiner of claim 26 wherein the magnitude of each one of the pair of offset portions at a distance of about one-half the length of its transverse region is between about one thousandth of an inch (0.05 mm) and about ten thousandths of an inch (0.25 mm).

28. The rotary disk refiner of claim 23 wherein the cross-sectional contour of each one of the pair of offset portions is within five percent of the result of the equation $y = -0.0048x + 0.0075$ where the variable y represents the magnitude of the offset and the variable x represents the location of the offset relative to a symmetry plane or midpoint of the deflection compensating conical disk refiner plate segment.

29. The rotary disk refiner of claim 23 wherein the cross-sectional contour of each one of the pair of offset portions is within five percent of the result of the polynomial equation $y = 0.0007x^3 - 0.0029x^2 - 0.0014x + 0.0068$ where the variable y represents the magnitude of the

offset and the variable x represents the location of the offset relative to a symmetry plane or midpoint of the deflection compensating conical disk refiner plate segment.

30. The rotary disk refiner of claim 1 wherein the deflection compensating refiner plate segment has a portion of its refining surface that is unsupported and the portion of the refining surface that is offset to compensate for deflection is disposed in that unsupported portion.

31. The rotary disk refiner of claim 30 wherein the rotary disk refiner is a conical disk refiner and the deflection compensating refiner plate segment comprises a deflection compensating conical disk refiner plate segment.

32. A refiner plate segment for a rotary disk refiner comprising:

a backside that includes a mounting portion that bears against or engages a mounting surface of the rotary disk refiner, the mounting portion providing support to the refiner plate segment;

a front side that includes a plurality of pairs of upraised and spaced apart refiner bars that defines a refining surface that is planar or that forms a segment of a conic section, the refining surface having a region that extends beyond the mounting portion such that the region is unsupported with the region deviating from planar or from the segment of the conic section to compensate for deflection of the refining surface that occurs during operation of the rotary disk refiner.

33. The refiner plate segment of claim 32 wherein the mounting portion comprises a dovetail mount, the refining surface has a pair of spaced apart regions each of which extends beyond the dovetail mount and each of which is unsupported, and the refining surface of each region is offset to compensate for deflection of the refining surface that occurs during operation of the rotary disk refiner.

34. The refiner plate segment of claim 33 wherein the refiner plate segment is a conical disk refiner plate segment with the refining surface forming the segment of the conic section and each offset region is offset from the segment of the conic section such that during operation of the rotary disk refiner, deflection of each offset region causes the refining surface in each offset region to substantially conform to the contour of the segment of the conic section such that the entire refining surface substantially conforms to the contour of the segment of the conic section.

35. The refiner plate segment of claim 32 wherein the refiner plate segment is a flat disk refiner plate segment that has a substantially planar refining surface except for a region deviating from planar, at least a portion of which is offset from planar to compensate for deflection during operation of the rotary disk refiner.

36. The refiner plate segment of claim 35 wherein the magnitude of the offset compensates for deflection of the refining surface during operation of the rotary disk refiner such that the entire refining surface becomes substantially planar during operation of the rotary disk refiner.

37. A refiner plate segment for a conical disk refiner comprising:

a front side that includes a plurality of pairs of upraised and spaced apart refiner bars that defines a refining surface that has a curvilinear transverse cross-sectional contour; and

a backside that comprises a pair of longitudinally extending mounting legs that are spaced apart to define a hollow therebetween that limits the deflection of that portion of the refining surface overlying the hollow.

38. The refiner plate segment of claim 37 wherein the pair of longitudinally extending mounting legs define a dovetail mount.

39. The refiner plate segment of claim 38 wherein the dovetail mount comprises a tenon that is received in a mortise of the conical disk refiner.

40. The refiner plate segment of claim 37 wherein the hollow has a concave transverse cross-sectional contour.

41. The refiner plate segment of claim 37 wherein the backside further comprises a pair of transversely extending and spaced apart ribs that are each disposed between the mounting legs.

42. The refiner plate segment of claim 41 wherein each one of the ribs extends from one of the mounting legs to the other one of the mounting legs.

43. The refiner plate segment of claim 42 wherein the hollow has a concave shape.

44. A method of making a deflection compensating refiner plate segment comprising:

29|407.01 SUR (a) providing a refiner plate segment that has a refining surface defining by a plurality

29|557, 558 of upraised and spaced apart refiner bars disposed on a front side of the refiner plate segment and a mounting surface that is capable of contacting a rotor of a rotary disk refiner;

(b) determining where the refining surface of the refiner plate segment deflects when subjected to a centrifugal force imparted on the refiner plate segment when the refiner plate segment is rotated at a rotational speed of 1500 rpm; and

(c) offsetting the refining surface in each portion of the refining surface where it has been determined that it deflects in step (b).

45. The method of making a deflection compensating refiner plate segment of claim 44 wherein (1) the deflection compensating refiner plate segment has a backside with a mount extending from the backside, (2) the refining surface has an overhang region that extends beyond the mount, and (3) at least a portion of the overhang region of the refining surface is offset to compensate for deflection that occurs during refiner operation.

46. The method of making a deflection compensating refiner plate segment of claim 45 wherein the portion of the overhang region of the refining surface that is offset, is offset at least about two thousandths of an inch (0.05 mm) relative to another portion of the refining surface.

47. The method of making a deflection compensating refiner plate segment of claim 45 wherein a transverse cross-sectional periphery of the majority of the refining surface defines a section of a circle, and the portion of the overhang region of the refining surface that is offset, is offset at least about two thousands of an inch (0.05 mm) relative to the section of the circle at a location of maximum offset.

48. The method of making a deflection compensating refiner plate segment of claim 47 wherein, during refiner operation at a rotational speed of at least 1500 rpm, the portion of the overhang region of the refining surface that is offset deflects such that substantially the entire refining surface defines the section of the circle.

49. The method of making a deflection compensating refiner plate segment of claim 47 wherein the magnitude of the offset of the portion of the overhang region that is offset corresponds to the function $y = 0.0007x^3 - 0.0029x^2 - 0.0014x + 0.0068$ wherein y is the magnitude of the offset and x is the transverse distance from a centerline or symmetry plane of the segment.

50. The method of making a deflection compensating refiner plate segment of claim 47 wherein the magnitude of the offset of the portion of the overhang region that is offset is within ±5% of the result of the function $y = -0.0048x + 0.0075$ wherein y is the magnitude of the offset and x is the transverse distance from a centerline or symmetry plane of the segment.

51. The method of making a deflection compensating refiner plate segment of claim 45 wherein the deflection compensating refiner plate segment has an edge, the overhang region extends outwardly to the edge, the portion of the overhang region of the refining surface that is offset has a maximum offset adjacent the edge that is at least two thousandths of an inch (0.05 mm).

52. The method of making a deflection compensating refiner plate segment of claim 51 wherein the maximum offset is no greater than fifteen thousandths of an inch (0.38 mm).

53. The method of making a deflection compensating refiner plate segment of claim 45 wherein the refining surface has a pair of overhang regions that each extending transversely beyond the mount and at least a portion of each overhang region of the refining surface is offset to compensate for deflection that occurs during refiner operation.

54. The method of making a deflection compensating refiner plate segment of claim 53 wherein the segment is a conical disk refiner plate segment that is mounted to a rotor of a conical disk refiner and rotated about an axis of rotation at a rotational speed of at least 1500

rpm during refiner operation.

55. The method of making a deflection compensating refiner plate segment of claim 44 wherein the method further comprises in step (b) determining the magnitude of the deflection.

56. The method of making a deflection compensating refiner plate segment of claim 55 wherein the refiner disk segment is modeled using finite element analysis in step (b).

57. The method of making a deflection compensating refiner plate segment of claim 56 wherein a transverse cross-section of the refiner plate segment is modeled by fitting a mesh to it and rotating it in a computer simulation at a rotational speed of 1500 rpm or greater.

58. The method of making a deflection compensating refiner plate segment of claim 57 wherein, before rotation of the modeled refiner plate segment in a computer simulation, boundary conditions for the modeled refiner plate segment are defined and include a density of about 7800 kg per cubic meter and a coefficient of friction between a mount of the modeled refiner plate segment and a refiner plate holder of about 0.2.

59. The method of making a deflection compensating refiner plate segment of claim 58 further comprising defining an additional boundary condition of between 5 to 10 atmospheres of steam pressure in a refining zone between the modeled refiner plate segment and a refiner plate segment opposing the modeled refiner plate segment.

60. The method of making a deflection compensating refiner plate segment of claim 56 wherein the magnitude and location of deflection of the refining surface is a result of the function $y = 0.0007x^3 - 0.0029x^2 - 0.0014x + 0.0068$ wherein y is the magnitude of the deflection and x is the transverse distance from a centerline or symmetry plane of the refiner plate segment.

61. The method of making a deflection compensating refiner plate segment of claim 56 wherein the magnitude and location of deflection of the refining surface is approximated by the function $y = -0.0048x + 0.0075$ wherein y is the magnitude of the deflection and x is the transverse distance from a centerline or symmetry plane of the segment.

62. The method of making a deflection compensating refiner plate segment of claim 61 wherein the magnitude and location of the deflection of the refining surface is within ±5% of the function $y = -0.0048x + 0.0075$.

63. The method of making a deflection compensating refiner plate segment of claim 44 wherein in step (b) the location and magnitude of refiner surface deflection is determined using a refiner plate segment that has a refining surface fitted with a plurality of pairs of refiner gap sensors that is rotated in a rotary disk refiner at a rotational speed of at least 1500 rpm to measure the refiner gap along the refining surface.

64. The method of making a deflection compensating refiner plate segment of claim 44 wherein in step (b) the location and magnitude of refiner surface deflection is determined and in step (c) an offset is applied to the refining surface in each location that is proportional to the determined magnitude.